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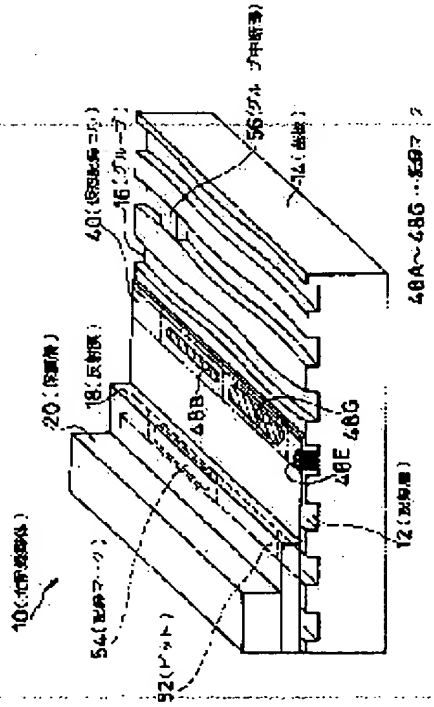
(54) OPTICAL RECORDING METHOD AND OPTICAL RECORDING MEDIUM

(57)Abstract:

PROBLEM TO BE SOLVED: To obtain an optical recording method and an optical recording medium suitable to multi-level recording.

SOLUTION: In the optical recording method for recording data by irradiating laser beams on the optical recording medium 10 having a recording layer 12 on a light transmissive substrate 14, a virtual recording cell 40 whose optional unit length in the moving direction S is H and moreover on which a unit recording mark 48 is recorded is continuously defined in the recording layer 12 in the moving direction S, further the laser beams are irradiated on plural virtual recording cells 40 in the state that laser beam irradiating power at a unit time is switched into five stages or more and the ratio of the minimum irradiating power ES to the maximum irradiating power EL satisfies the relation of 0.05<ES/EL<0.5, and plural recording marks 48A-48G different in



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* NOTICES *

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CLAIMS

[Claim(s)]
[Claim 1] The optical-recording approach characterized by for related T=P1/P2 of the duty ratio (P1) in the maximum exposure power of a laser beam when carrying out multi-level record and the duty ratio (P2) in the minimum exposure power to fill 0.5< T<0.9 with switching the exposure power of a laser beam to five or more steps, and irradiating said laser beam at the optical recording medium which has a record layer on a light transmission nature substrate according to the data with which record is presented.
[Claim 2] It is the optical recording approach which records data by the exposure of a laser beam to the optical recording medium which has a record layer on a light transmission nature substrate. It is set as said record layer by the unit width of face of the arbitration of the direction which intersects perpendicularly with the unit length of the arbitration of the direction of relative movement with said laser beam, and this. And specify continuously the virtual record cel by which record of a unit record mark is enabled in said migration direction, and said further two or more virtual record cels are received. The exposure power of the laser beam with which record is presented is switched to five or more steps. and unit time amount is irradiated about each virtual record cel -- this -- the ratio of the maximum exposure power EL in five or more steps of exposure power and the minimum exposure power ES The optical recording approach characterized by irradiating said laser beam in the condition that the relation of 0.05<ES/EL<0.5 is filled, and forming two or more record marks from which at least one side differs among magnitude and light transmittance.
[Claim 3] The optical recording approach characterized by including the record mark used as the die length below the diameter of the condensing beam of reading laser in the record mark of said plurality from which the magnitude formed of the exposure of said laser beam differs in claim 1 and 2.
[Claim 4] The optical recording approach characterized by the record layer of said optical recording medium mainly consisting of organic coloring matter in claims 1 and 2 or 3.
[Claim 5] The optical recording medium characterized by enabling formation of said record mark by the optical recording approach according to claim 1, 2, or 3 while being the optical recording medium which has a record layer and constituting said record layer including organic coloring matter on the light transmission nature substrate.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] According to the data with which record is presented, this invention changes the exposure power of a laser beam to a multistage story, irradiates an optical recording medium, and relates to the optical recording approach and optical recording medium which form the record mark corresponding to exposure power, and carry out multi-level record of said data.
[0002]
[Description of the Prior Art] Many researches on the approach of recording two or more data on the field of the same die length are made to the approach of recording data by changing the depth (modulation factor of a reflective signal) of a record mark to a multistage story by changing die length (the die length of the reflective signal modulation section) of a record mark like the conventional optical recording medium into a multistage story.
[0003] Since two or more data are recordable in the depth direction as compared with the case where data binary [by the existence of a pit] are only recorded according to this optical recording approach, the amount of the signal assigned to fixed die length can be increased. Therefore, since track recording density can be improved, the thing using a holograph and the optical recording approach which made the record layer the multilayer are proposed.
[0004] Here, the case where data are recorded on a multistage story using depth fluctuation of a reflection factor etc. is called multi-level record.
[0005]
[Problem(s) to be Solved by the Invention] In such multi-level record, for improving recording density, it is necessary to shorten a record mark.
[0006] However, when it is going to make a record mark smaller than a beam diameter when the laser beam used for record and reading condenses, multi-level record becomes difficult.
[0007] For example, JP,10-134353,A has the publication of the purport which adjusts the laser-beam quantity of light, in order to record a multi-level. Here, in the case of the coloring matter film or the phase change film, the record medium forms the regenerative signal by the difference in an echo in a record part and a non-recorded part. Therefore, by the approach of JP,10-134353,A, the phase where it does not record, and a record phase have the relation of record existence, and it has not turned [phase] to record of a multistage story. Speaking more concretely, the intermediate state which is not recorded [record and] existing neither by the phase change film nor the coloring matter film.
[0008] Moreover, when the amount of incident light to a record layer is given as a digital variable so that it may be indicated by JP,1-182846,A, for example, there is an optical recording medium from which the absorbance of the reactant in a record layer changes as a digital variable.
[0009] However, it is guessed that the absolute value of the absorbance change to a laser-beam dose (count) is dramatically small, and this optical recording medium has not yet resulted in utilization.
[0010] Furthermore, there is the optical recording approach recorded on the coloring concentration condition of the phase of arbitration which the exposure luminous intensity or the count of an exposure

which irradiates a photochromic ingredient is changed, and is different so that it may be indicated by JP,61-211835,A.
[0011] However, by this optical recording approach, in case laser-beam light is irradiated and is read, there is a trouble that a coloring concentration condition cannot be read to five or more steps.
[0012] Although it thinks that the above problem is the result of all elements, such as the property of exposure power setting out of a laser beam and a record medium, becoming entangled intricately, as far as this invention person gets to know, the cause is not clarified now, but the actual condition is that multi-level record of high density is not attained including the record medium and the record approach.
[0013] this invention person discovered the approach in which five or more steps of multi-level records are possible by changing laser-beam exposure power also under conditions which are shorter than a condensing beam diameter. It discovered that the direction of a coloring matter ingredient with a change looser than a phase change ingredient with the steep change to the record from un-recording furthermore followed on the temperature rise in a laser-beam exposure as an ingredient of record film is also suitable.

[0014] This invention uses an optical recording medium like CD-R generally put in practical use widely in consideration of the above-mentioned thing, performs multi-level record of a multistage story, and aims at offering the optical recording approach and optical recording medium which make it possible to acquire a good signal quality.
[0015]
[Means for Solving the Problem] When this invention person changes five or more steps of the exposure power of the laser beam at the time of record as a result of repeating research wholeheartedly about the multi-level record approach using the optical recording medium which has an organic-coloring-matter record layer, and multi-level record is carried out, the record approach in which the multi-level record whose exposure power of the laser beam at the time of record has equal almost uniform record mark area as compared with a small part also in a part with the large exposure power of the laser beam at the time of record is possible found out. This is attained by controlling the duty ratio in the laser-beam exposure power at the time of each record.
[0016] It will be said that duty ratio is a ratio of the exposure power of the laser beam to the unit chart lasting time of the pit formed of record to irradiate, for example, duty ratio is 70% when forming with outputting the record signal of the exposure power of 7, in order to form the pit of the depth of 10 in the depth direction. To the record layer at this time, if it records at 100% of duty ratio, the die length of a pit will become deeper than 10.
[0017] this invention person repeated research wholeheartedly about the optical recording medium, found out the record approach which modulates the rate of a light reflex of the whole virtual record section of a fixed area which the rate of a light reflex around a record mark included to the high field on a multistage story, and checked that it was possible to perform multi-level record of five or more steps of high density to an optical recording medium by this record approach. That is, achievement of the above-mentioned object is attained by the following this inventions.
[0018] (1) The optical-recording approach characterized by for the relation (T) between the duty ratio (P1) in the maximum exposure power of a laser beam when carrying out multi-level record and the duty ratio (P2) in the minimum exposure power to fill a formula (1) with switching the exposure power of a laser beam to five or more steps, and irradiating said laser beam at the optical recording medium which has a record layer on a light transmission nature substrate according to the data with which record is presented.
[0019] $0.5<T<0.9$ (1)
(Being here $T=P1/P2$)
[0020] (2) It is the optical recording approach which records data by the exposure of a laser beam to the optical recording medium which has a record layer on a light transmission nature substrate. It is set as said record layer by the unit width of face of the arbitration of the direction which intersects perpendicularly with the unit length of the arbitration of the direction of relative movement with said laser beam, and this. And specify continuously the virtual record cel by which record of a unit record

mark is enabled in said migration direction, and said further two or more virtual record cels are received. The ratio of the maximum exposure power EL in a switch and five or more steps of laser radiation power which irradiates unit time amount about each virtual record cel, and the minimum exposure power ES the exposure power of laser to five or more steps The optical recording approach characterized by irradiating said laser beam in the condition that the relation of a formula (2) is filled, and forming two or more record marks from which at least one side differs among magnitude and light transmittance.

[0021] $0.05 \leq ES/EL \leq 0.5$ (2)

[0022] (3) The optical recording approach characterized by including the record mark used as the die length below the diameter of the condensing beam of reading laser in the record mark of said plurality from which the magnitude formed of the exposure of said laser beam differs.

[0023] (4) The optical recording approach of of (1) characterized by the record layer of said optical recording medium mainly consisting of organic coloring matter.

[0024] (5) The optical recording medium characterized by enabling formation of said record mark by the optical recording approach of a publication at either of (1) - (4) while being the optical recording medium which has a record layer and constituting said record layer including organic coloring matter on the light transmission nature substrate.

[0025] In this invention, it records by irradiating the laser beam which changed exposure power into the optical modulator through delivery and this light modulation machine in five or more steps as a modulating signal of the content of changing the exposure power of a laser beam into five or more steps for the signal which changes with the data with which record is presented from a modulating-signal generator at the optical recording medium concerned. By carrying out like this, five or more steps of information is recorded in the depth direction by the record part of fixed die length, and it becomes possible to make it change to five or more steps also of the amount of reflected lights of a laser beam irradiated at the time of playback.

[0026] If exposure power of the laser beam to irradiate is extremely enlarged as compared with formation of a shallow record mark in order to form a deep record mark, record mark area will spread, and if exposure power of a laser beam is made small, it will become impossible however, to record sufficient depth on reverse. It inquires in the time of forming the time of forming the duty ratio of the laser beam to irradiate in consideration of this at the time of the maximum exposure power and the minimum exposure power, i.e., a deep record mark, and a shallow record mark, and the above-mentioned relational expression (1) is drawn.

[0027] Although the case where the duty ratio of the maximum exposure power is too large, or the duty ratio of the minimum exposure power is too small can be considered in this relational expression when becoming 0.9 or more In the case of the former, according to aggravation of the record signal by the breadth of record mark area, informational playback is not performed normally, in the case of the latter, record in the depth direction may not fully be performed, and, similarly informational playback may not be performed normally. Moreover, although the case where the case of 0.5 or less has the too small duty ratio of the maximum record power, or the duty ratio of the minimum exposure power is too large can be considered, in the case of the former, informational playback may not be normally performed by fully not performing record in the depth direction, and, similarly, in the case of the latter, informational playback may not be normally performed by aggravation of the record signal by the breadth of record mark area.

[0028] Moreover, in this invention, since the virtual record cel was assumed in the record layer and the rate of a light reflex of that whole virtual record cel was read, even when a record mark became smaller than the diameter of a laser beam, the reflection factor could be controlled on the multistage story by adjusting the exposure power of a laser beam to a multistage story. That is, where the cel set as the object of reading is fixed, in modulating laser-beam exposure power, either [at least] the magnitude of a record mark or light transmittance was modulated, and record of a multi-level was attained by changing the level of the rate of a light reflex in the whole fixed field (virtual cel) including a record mark to a multistage story.

[0029] This effectiveness was still more remarkable at the time of five or more steps of multi-level records.
[0030] That is, when it was to about four steps, record of a multi-level was possible also by the approach of modulating the die length of the usual record mark. However, in case multi-level record of five or more steps of high density is performed, it is important to control the rate of a light reflex of the whole virtual cel.
[0031] However, it became clear by only modulating the exposure power of a laser beam that the record mark may be unable to be read certainly only by forming a record mark. Then, when dedicating the ratio of the maximum exposure power and the minimum exposure power within the limits of the above-mentioned relational expression (2) as a result of this invention person's further analysis, it found out that the reading precision was raised substantially. In addition, this minimum exposure power is exposure power required to obtain the highest reflection factor in the reflection factor set as five or more steps, and the maximum exposure power is exposure power which is needed for obtaining the minimum reflection factor.
[0032] For example, if exposure power of the laser beam for record is extremely enlarged in order to form the record mark to which the reflection factor of a virtual record cel is reduced greatly, as compared with formation of the high record mark of a reflection factor, record mark area will spread too much and a signal quality will deteriorate. If exposure power of a laser beam is extremely shortened in order to consider as the high virtual record cel of a reflection factor, it will become impossible on the contrary, to record sufficient depth.
[0033] In order to perform five or more steps of multi-level records, a certain amount of exposure power field (the minimum exposure power - maximum exposure power) is needed. By setting up the ratio of the minimum exposure power of a laser beam and the maximum exposure power to irradiate within the limits of the above-mentioned relational expression (2) in consideration of this, a kind of constraint tends to be imposed on exposure exposure power, and it is going to control becoming too large exposure power and too small exposure power. That is, the conditions which must be examined in the time of the minimum reflection factor of a virtual record cel and maximum reflectance are added, and it assumes raising the record precision.
[0034] When becoming 0.05 or less in this relational expression (2), a conclusion that the maximum exposure power is too large or the minimum exposure power is too small can be drawn easily. In the case of the former, informational playback is not normally performed by aggravation of the signal quality of the low virtual record cel (record mark) of a reflection factor, in the case of the latter, record of the high virtual record cel (record mark) of a reflection factor serves as imperfection, and informational playback is not performed normally.
[0035] Moreover, in this relational expression (2), the case of 0.5 or more can draw easily a conclusion that the maximum exposure power is too small or the minimum exposure power is too large. In the case of the former, record of the low virtual cel (record mark) of a reflection factor serves as imperfection, informational playback is not performed normally, and, in the case of the latter, informational playback is not normally performed by aggravation of the signal quality of the low virtual record cel (record mark) of a reflection factor.
[0036] That is, if this relational expression (2) is used, record power can be set up very rationally (correction).
[0037] By the optical recording approach of this invention shown above, since the signal property in the case of multi-level record can be made good and exposure power is changed further, only the part can make a record mark small. It is desirable that the exposure power of a laser beam is specifically read to a part of record mark switched and formed in five or more steps, and the record mark of the die length below the diameter of the condensing beam of laser is made to be included. If it does in this way, as compared with the former, recording density can be raised by leaps and bounds.
[0038] In addition, it is set as $0.04<ES/EL<0.6$ especially preferably within the limits of the above-mentioned relational expression (2), and also $0.05<ES/EL<0.5$ are desirable. In addition, when the properties of a record medium differ, the values of the ratio of the above-mentioned relational

expression (2) differ. Moreover, even if it is the same record medium, when laser-beam irradiation time differs, the values of the ratio of the above-mentioned relational expression (2) may differ. Therefore, it is desirable that the above-mentioned relational expression is made to be filled suitably in consideration of the property and laser-beam power of a record medium.

[0039] For example, when forming a record mark in each virtual record cel so that it may become five or more steps of reflection factors if its attention is paid to the property of a record medium, the virtual record cel used as the highest reflection factor and the virtual record cel used as the minimum reflection factor exist in it. The exposure power by laser radiation has the smallest thing to the virtual record cel of the highest reflection factor, and its thing to the virtual record cel of the minimum reflection factor is the largest. If a medium with a large change (lowering) of the reflection factor to exposure power, i.e., a medium easily recordable in a short time, is used for a record layer, as a result of the minimum exposure power and the maximum exposure power approaching it here, the value of relational expression (2) becomes large. After all, control of the reflection factor by exposure power does not become difficult, or a record mark becomes large too much and the record medium with which this becomes 0.5 or more [of the above-mentioned relational expression (2)] does not turn to a multiple-value record medium.

[0040] Conversely, if change (lowering) of a reflection factor uses a small medium to exposure power, the value of relational expression (2) will become small. The record medium with which this becomes 0.05 or less has high possibility that data detection includes the difficult minute record mark, and does not turn to a multiple-value record medium too.

[0041] Consequently, the meaning "sorting of an optical recording medium" is included in the optical recording approach of this invention. In order for this to fill the above-mentioned relational expression (2), it is because coexistence of a record medium and the record approach is needed, and when compatible, this invention is realized and the detection precision of data is raised actually.

[0042] Moreover, by the optical recording approach concerning the above-mentioned invention, the property of itself is suitable for multi-level record, and, as for the optical recording medium whose record was enabled, the above-mentioned object can be attained. As for the record layer in that case, it is desirable to make it constituted including organic coloring matter, and it is checked that five or more steps of multi-level records are actually attained by this invention person.

[0043] In addition, this invention may be constituted as follows.

[0044] (6) (2), or the (3) optical-recording approaches which changes the magnitude of the record mark formed in said virtual record cel, modulates the rate of a light reflex in this whole virtual record cel by surface ratio according to the exposure power of said laser beam, and is characterized for information by five or more steps of things to do for multi-level record at least among the light transmittance of the surface ratio to a virtual record cel, and a record mark.

[0045] (7) The optical recording approach of of (6) characterized by constituting from an ingredient with which magnitude is modulated at least among the magnitude of a record mark, and light transmittance, fixing the beam diameter of a laser beam and irradiating it only by responding to the exposure power when seting the beam diameter of a laser beam constant for said record layer.

[0046] (8) The optical recording medium of (5) characterized by the set-up thing on which the unit length of said virtual record cel spreads the die length of a record mark, abbreviation, etc. which are formed of the laser-beam exposure of said maximum exposure power.

[0047] (9) It is the optical recording medium of (5) or (8) characterized by having prepared the groove for laser beamguides, and having set up said virtual record cel in said groove along with said record layer, and said unit width of face being in agreement with the width of face of said groove.

[0048] (10) finishing [layer / said / a part of / record / multi-level record of information] beforehand -- it is -- the optical recording medium of (5), (8), or (9) characterized by things.

[0049] (11) The optical recording medium of (5), (8), or (9) characterized by recording the specific information which shows that it is a multi-level record medium at least on one side of said virtual record cel and the part recorded [multi-level].

[0050] (12) The optical recording medium of either [which is characterized by having prepared the groove for laser beamguides and this groove having broken off partly along with said record layer] (5),

(8) or (10).
[0051]
[Embodiment of the Invention] A light transmission nature substrate applicable to this invention can be chosen as arbitration from various kinds of ingredients used for the conventional optical recording medium. For example, although polycarbonate resin, polymethylmethacrylate resin, an epoxy resin, amorphous polyolefin resin, polyester resin, etc. are applicable, points, such as moisture resistance, dimensional stability, and a price, to polycarbonate resin is desirable. It is desirable that the irregularity (a pre groove and pit) showing information, such as a slot for tracking or an address signal, is formed on this light transmission nature substrate, and this irregularity can obtain resin ingredients, such as polycarbonate resin, by imprinting the irregularity of a matrix (stamper) injection molding or by carrying out extrusion molding.
[0052] In order to perform record playback of the optical recording medium concerned more appropriately, information is variously included in this concavo-convex information. Such information is performing multi-level record, in case a light transmission nature substrate is formed when being beforehand recorded by forming two or more pits where the information is imprinted from the above-mentioned stamper, and the depth differs, or after the optical recording medium concerned is produced, and it can record the information. ID information for recognizing variously that above it is the optical recording medium concerned according to an individual as information, The optical-recording-medium class identification information for identifying that the optical recording medium concerned is an optical recording medium for multi-level record, information required for record playback of the information for determining the power of the laser beam for carrying out record playback of the record medium concerned etc. -- further There are a hour entry of the content by which multi-level record was carried out, the address information, table-of-contents information that it means what kind of content the information is where of the optical recording medium concerned, and is recorded, etc., and such information can be used at the time of record of the optical recording medium concerned, and/or playback. In addition, in the case of a disk-like medium, such information should just carry out preparing more than one according to a fixed regulation on the disk near the outermost periphery near the most inner circumference etc.
[0053] An organic-coloring-matter record layer is prepared on said light transmission nature substrate. An organic-coloring-matter record layer can apply cyanine system coloring matter, squarylium system coloring matter, crocodile NIUMU system coloring matter, anthraquinone system coloring matter, metal-containing azo dye, phthalocyanine system coloring matter, naphthalocyanine system coloring matter, etc.
[0054] As a solvent for organic-coloring-matter coating liquid, ester; methyl ethyl ketones, such as butyl acetate and a cellosolve acetate, Ketones, such as a cyclohexanone and methyl isobutyl ketone; Dichloromethane, Hydrocarbons [, such as chlorinated-hydrocarbons; dimethylformamide, /, such as an amide; cyclohexane,], such as 1,2-dichloroethane and chloroform; A tetrahydrofuran, Ether, such as ethyl ether and dioxane; Ethanol, n-propanol, Fluorine system solvents, such as alcohols;2, such as isopropanol, n-butanol, and diacetone alcohol, 2 and 3, and 3-tetrafluoro propanol; Ethylene glycol monomethyl ether, glycol ether, such as ethylene glycol monoethyl ether and propylene glycol monomethyl ether, is usable, and they are independent in consideration of the solubility of the organic coloring matter which uses these solvents etc. -- or it can be mixed and used. In coating liquid, you may add [for the purpose of various kinds of additives such as a singlet oxygen quencher, an antioxidant, UV absorbent, a plasticizer, and lubricant,] further.
[0055] Thus, generally the concentration of the organic-coloring-matter coating liquid prepared is 0.1 - 5 % of the weight preferably 0.01 to 10% of the weight. As the method of application, although a spray method, a spin coat method, a dip method, the roll coat method, the blade coat method, the doctor roll method, screen printing, etc. can be mentioned, a spin coat method is desirable especially, and it forms so that the thickness of the organic-coloring-matter record layer after desiccation may generally be set to about 20-500nm.
[0056] Although a light reflex layer is prepared on the above-mentioned organic-coloring-matter record

layer, the light reflex nature matter which is the ingredient of a light reflex layer has the desirable matter with the high reflection factor to laser-beam light, and as the example, elements, such as Au, Ag, Cu, aluminum, nickel, Pd, Pb, Pt, Cr, nickel, and Pt, are raised, and it is formed with the sputtering method or a vacuum deposition method, using these as independent or an alloy. Generally the thickness of a light reflex layer is 10-800nm, and is 50-300nm preferably.

[0057] On a light reflex layer, a protective layer is prepared in order to protect physically and chemically an organic-coloring-matter record layer, a light reflex layer, etc. This protective layer may be prepared in order to raise ****-proof and moisture resistance also to the side in which the organic-coloring-matter record layer of a light transmission nature substrate is not prepared. Generally ultraviolet-rays hardenability resin is widely used for the protective layer, and after dissolving in a solvent remaining as it is or suitable and preparing coating liquid, this coating liquid is applied and it forms by irradiating ultraviolet rays and stiffening them. In these coating liquid, you may add [for the purpose of various additives, such as an antistatic agent, an antioxidant, and an ultraviolet ray absorbent,] further. The thickness of a protective layer is about 0.1-100 micrometers.

[0058] Although the optical-recording medium used for this invention may be an optical recording medium of the veneer type which consists of the above-mentioned configuration The optical recording medium of two sheets which has the above-mentioned configuration further or by joining using facing each other, adhesives, etc. so that a protective layer may serve as the inside It can also consider as a lamination type optical recording medium, and can also consider as the optical recording medium of the lamination type obtained by joining to at least one side among the optical recording media of two sheets using the optical recording medium which has the above-mentioned configuration.

[0059] Thus, the record approach to the optical recording medium obtained For example, rotating an optical recording medium with a constant linear velocity or a constant angular velocity using the semi-conductor laser beam which has the wavelength of the range of 770-790nm, and the wavelength of the range of 630-660nm as a record light It is carried out when organic coloring matter deteriorates by irradiating the laser beam which was suitable for the organic-coloring-matter record layer at it, and the playback approach is performed by reading the difference of the amount of reflected lights of the light of the part into which organic coloring matter deteriorated, and the part which is not so.

[0060] In this invention, the input signal which changes further with the data with which record is presented is changed into five or more steps of modulating signals by the modulating-signal generator, and this modulating signal is recorded by changing the power of a laser beam to an optical modulator at five or more steps, and irradiating it through delivery and this optical modulator, at the optical recording medium concerned at it. By carrying out like this, multi-level record of five or more steps of the information is carried out in the depth direction, and it becomes possible [the amount of reflected lights obtained by the laser beam irradiated at the time of playback] to make it change in five or more steps at the record part of fixed die length. That is, rotating the optical recording medium by which multi-level record was carried out with a constant linear velocity or a constant angular velocity, a laser beam 1mW or less is irradiated preferably, and since it is reproducible exposure power smaller than the exposure power of the laser beam at the time of record, and by detecting the reflected light, the amount of information per unit length and also the amount of information per unit area increase by leaps and bounds.

[0061] Furthermore, by having beforehand two or more pits of a number of depth doubled with the number of stages of the exposure power of a laser beam in the optical recording medium concerned, or performing multi-level record beforehand to some of optical recording media concerned The information which identifies the record medium concerned according to an individual into two or more of these pits and/or the part recorded [multi-level], It has specific information, such as information for determining the exposure power of the laser beam for carrying out record playback of the information which identifies that it is an optical recording medium for multi-level record, and the record medium concerned. The specific information by reading at the time of the optical-recording-medium playback concerned and/or record Since it can identify certainly that it is an optical recording medium for multi-level record, they can be further identified according to an individual or the number of stages of the

exposure power of a laser beam can be determined according to the number of stages of the pit currently recorded beforehand, More positive multi-level record playback can be performed.
[0062] The example of the gestalt of still more concrete operation of this invention is explained to a detail with reference to a drawing below.
[0063] The optical recording medium (disk) 10 with which the optical recording approach concerning the example of the gestalt of operation of this invention is applied The substrate 14 which is CD-R which used coloring matter for the record layer 12, and consists of a transparence base material, Said record layer 12 which consists of coloring matter which covered the groove 16 for laser beamguides formed in one field (it sets to drawing 1 and is a top face) of this substrate 14, and was applied, The outside of the reflective film 18, such as gold formed of sputtering etc. or silver, and this reflective film 18 is formed in this record layer 12 upside including the wrap protective layer 20.
[0064] The coloring matter used for said record layer 12 is organic coloring matter, such as cyanine, merocyanine, methine system coloring matter and its derivative, a benzenethiol metal complex, phthalocyanine dye, naphthalocyanine dye, and azo dye.
[0065] Multi-level record to said optical recording medium 10 is performed by the optical recording equipment 30 shown in drawing 2 .
[0066] This optical recording equipment 30 is a CD-R recorder, carries out revolution actuation of the optical recording medium (disk) 10 on condition that a constant linear velocity with a spindle motor 32 through the spindle servo 31, and records information on an optical recording medium (disk) 10 by the laser beam from laser 36.
[0067] According to the information which should record said laser 36, the laser-beam exposure power per one of the virtual record cel (detail after-mentioned) 40 shown in drawing 1 and drawing 3 is electrically controlled by the laser driver 38. In addition, control (modulation) of the exposure power of a laser beam may use the modulators 41 other than electric control of an electrical-potential-difference modulation etc., such as a polarizing element, an acoustooptic modulator, and an electrooptical modulator.
[0068] The sign 42 of drawing 2 is the record optical system containing objective lens 42A and half mirror 42B. Focal tracking control of the objective lens 42A is carried out so that a laser beam may condense in the record layer 12 of a disk 10 by the focal tracking servo 44. Moreover, synchronizing with a revolution of a disk 10, migration control of objective lens 42A and the half mirror 42B is carried out by the feeding servo 46 at a predetermined rate from the inner circumference side at a periphery side.
[0069] Said spindle servo 31, the laser driver 38, the focal tracking servo 44, and a feeding servo 46 are controlled by the control unit 50. The data (information) which should be recorded on the record layer 12 are inputted into a control unit 50.
[0070] Next, the optical recording approach is explained to a detail, including explanation of said virtual record cel 40.
[0071] This virtual record cel 40 is specified to the unit width of face of the direction of a path of a record medium, and the unit length of a hand of cut. Unit width of face is the width of face which makes below the beam waist diameter of a laser beam, and can be chosen as arbitration, such as a track pitch, group width of face, etc. of a disk 10.
[0072] As the virtual record cel 40 of the example of the gestalt of this operation is shown in drawing 1 And width of face is equally specified as croup 16. the inside of said groove 16 -- die length (the die length of a circumferencial direction) shorter, the hand of cut, i.e., the circumferencial direction, of a disk 10, than beam diameter (diameter of beam waist) D -- He is trying to be formed in drawing 3 according to the information which should record the record marks 48A-48G illustrated typically by assuming continuously to a circumferencial direction and irradiating a laser beam every virtual record cel 40.
[0073] Here, although beam diameter D in record layer 12 location of the laser beam by which outgoing radiation is carried out from said laser 36 is made larger than said virtual record cel 40, it can form in the core of a laser beam the light transmittance modulation field 48A-48G where diameters differ, i.e.,

record marks, by choosing the ingredient of the record layer 12 according to laser-beam exposure power. Here, although the laser beam is circular, since a laser beam is irradiated rotating an optical recording medium 10, when the circular core of a laser beam is displaced relatively within the virtual record cel 40 by irradiation time, it becomes an ellipse and the width of face of the direction of a path becomes large according to the exposure power of a laser beam.

[0074] Because, although the optical reinforcement generally makes Gaussian distribution, the laser beam by which focusing was carried out Since record is performed only in the part which exceeded the threshold with the exposure energy of a laser beam in the record layer 12 By changing the exposure power of a laser beam, a spot size of a laser beam recordable on the record layer 12 changes, and formation of seven steps of record marks 48A-48G as shown, for example in drawing 3 by this is attained. However, the light transmittance within each record mark 48A-48G is not uniform, and, more generally a core becomes low.

[0075] In this case, the magnitude of the range exceeding the threshold of the exposure energy in a laser beam, i.e., each magnitude and light transmittance of the record marks 48A-48G, is set up so that the rate of a light reflex of the reflected light in the whole containing the record mark in the virtual record cel 40 when reading to the virtual record cel 40 and irradiating a laser beam and the non-recorded part of that perimeter may become seven steps. Said rate of a light reflex becomes so large that a record mark is small, and turns into the minimum reflection factor in the virtual record cel in which maximum reflectance and the record mark 48G [greatest] are formed in the virtual record cel in which the record mark is not formed.

[0076] Furthermore, said rate of a light reflex is set to a detail in consideration of the light transmittance of the surface ratio to the virtual record cel 40 of each record marks 48A-48G, and the record mark itself.

[0077] The ingredient which constitutes the record layer 12 carries out decomposition deterioration by the exposure of a laser beam, and the light transmittance of record mark 48A - 48G the very thing changes with variation of the case where the refractive index changes, and the thickness direction of the record layer 12. If the light transmittance of the formed record mark part is zero, it is not necessary to take this into consideration.

[0078] Here, further, the ratio of the maximum exposure power EL in seven steps of laser-beam exposure power (this is a value in the case of record mark 48G formation) and the minimum exposure power ES (this is a value in the case of record mark 48A formation) is set up so that the relation of $0.05<ES/EL<0.5$ (... relational expression (1)) may be filled. Consequently, the signal property in the case of reading can be made good. Therefore, as shown in drawing 3 , even if only the part can make a record mark small now and forms the record mark (here all record marks 48A-48G) of the die length below the diameter D of the condensing beam of reading laser, data reading is fully possible.

[0079] In addition, by this invention, although the example of the gestalt of this operation showed the case where all record marks were made below into the diameter D of a condensing beam, when it is not limited to it but a part of record mark becomes below the diameter D, and also when all record marks become more than condensing beam diameter D, it contains.

[0080] Here, the record mark may be unable to be certainly read only by forming a record mark by modulating the laser-beam exposure power at the time of record. However, by this optical recording approach, since the ratio of the minimum record power ES and the maximum record power EL is dedicated within the limits of the above-mentioned relational expression (1), the reading precision is raised substantially.

[0081] In order to perform five or more steps of multi-level records, it is necessary to set up a certain amount of exposure power field (the minimum exposure power ES - the maximum exposure power EL). Since a kind of constraint is given in that case so that the ratio of the minimum exposure power and the maximum exposure power may be set as predetermined within the limits, becoming too large exposure power and too small exposure power is controlled. That is, record power is set up very rationally by this relational expression (1) (correction).

[0082] Thus, as already explained to the virtual record cel 40 by having set up, as fixed, irradiation time

switches the exposure power of a laser beam to five or more (the above-mentioned example seven steps) steps, the multi-level record of it is attained, and even if it makes it the die length of the record marks 48A-48G of multi-level record become below the diameter D of the condensing beam waist of reading laser, the data detection of it is certainly attained especially.

[0083] Consequently, the optical recording medium which can record a high consistency is obtained from the ability of the very small record mark which becomes below a condensing beam waist to be generated to them, as reflection factors differ in five or more steps.

[0084] Moreover, in the above-mentioned invention, it is desirable that said record layer of said optical ~~recording medium is constituted including an organic coloring matter component. The above-mentioned~~ multi-level record is actually attained by the approach of generating a record mark by the reaction of an organic-coloring-matter component so that it may explain in the below-mentioned example.

[0085] Moreover, this optical recording approach also contains implications called sorting of a disk 10. This is because coexistence of an optical recording medium 10 and the record approach is needed in order to fill the above-mentioned relational expression (1). Therefore, it can be said that the disk 10 with which this relational expression (1) is realized fits multi-level record.

[0086] Moreover, in the example of the gestalt of the above-mentioned implementation, although the record layer 12 uses organic coloring matter, such as cyanine, as long as this invention is a thing of a property which fills the above-mentioned relational expression (1), it may be enough, it is not limited to this, they may be the organic coloring matter or the inorganic coloring matter other than the above, and even if it uses other ingredients suitably, it is not cared about. However, when the above organic coloring matter was used, corresponding to five or more steps of irradiation time of a laser beam, the magnitude of a record mark was able to be changed certainly, and it could record, and was able to read in a very high precision.

[0087] Furthermore, although the example of the gestalt of the above-mentioned implementation is a thing about the optical recording medium 10 including the non-record section where the information on data etc. is not recorded, this invention is not limited to this and applied also to the optical recording medium with which multi-level record of the information is carried out in five or more steps.

[0088] Furthermore, the size of the virtual record cel 40 set up on the record layer 12 again in case a record mark is formed with the above-mentioned optical recording equipment 30 is not limited to the example of the gestalt of operation. If the diameter of a beam waist of a laser beam can be extracted especially still smaller, die length is best to make it equal to the width of face of a groove 16. On the other hand, when recording a record mark on the further multistage stories, such as eight etc. steps, you may set up more than the laser-beam waist. In that case, a part of some record marks can be made into the magnitude more than a beam waist. Of course, also in the optical recording medium which does not have a groove 16, this invention is applicable.

[0089] In addition, although what constituted the optical recording medium 10 from an example of the gestalt of this operation as mentioned above as a disk which is CD-R was shown, this invention is not limited to this and, generally is applied to other optical recording media.

[0090] Moreover, although said laser beam is almost circular in the location of the record layer 12, the shape of beam is short to the feed direction of a record medium 10, and you may make it this turn into a long ellipse configuration or a long line in this and the rectangular direction using cylindrical-lens 42C in addition to objective lens 42A, as is shown in drawing 4 . In this case, since the record mark 49 becomes short, a virtual record cel can be shortened further. That is, recording density can be raised.

[0091] Furthermore, in this optical recording medium 10, as drawing 1 is shown by the sign 52, you may make it have two or more pits where a number of reflection factors doubled with the number of stages of a signal modulation differ beforehand, or multi-level record by the optical recording approach of this invention may be beforehand performed to some of optical recording media concerned. Specific information, such as information for determining the recommendation record power of the laser beam for carrying out record playback of the information which identifies the record medium concerned according to an individual, the information which identifies that it is an optical recording medium for multi-level record, and the record medium concerned, may be recorded on two or more of these pits 52

and/or the record mark 54 of the part recorded [multi-level]. By reading at the time of the optical-recording-medium playback concerned and/or record, the specific information can identify certainly that it is an optical recording medium for multi-level record, can identify them according to an individual further, or can determine the exposure power of a laser beam according to the number of stages of the pit currently recorded beforehand, and can perform more positive multi-level record and playback.
[0092] Or as shown to drawing 1 by the sign 56, the same effectiveness can also be given also by preparing the groove interruption section which makes a part of groove for laser beamguides break off. These approaches are independent or combining and using is also possible.
[0093]
[Example] Below the example of this invention is shown and this invention is explained to it.
[0094]
[Example 1] Dissolve cyanine dye in fluorination alcohol and 2% of coating liquid for record stratification is prepared. It is a spiral-like pre groove (track pitch: 1.6 micrometers) to a front face about this coating liquid. Pre groove width of face : The diameter of 120mm which 0.35 micrometers and depth:0.18micrometer of a pre groove become from the polycarbonate (Made in formation [Teijin] : the panlight AD 5503) formed of injection molding, It applied to the pre groove side front face of the light transmission nature substrate of 1.2mm thickness with the spin coat method, making it change to rotational frequency 200rpm - 5000rpm, and the organic-coloring-matter record layer whose thickness from the pars basilaris ossis occipitalis in a pre groove is about 200nm was formed in it. In addition, what recorded beforehand the distinction signal which shows that this optical recording medium is used for multi-level record, and the information signal about laser-beam exposure power was used for the light transmission nature substrate used here.
[0095] Next, on the organic-coloring-matter record layer, about 100nm sputtering of Ag was carried out, and the light reflex layer was formed. Furthermore, it applied with the spin coat method, changing ultraviolet-rays hardenability resin (Dainippon Ink & Chemicals, Inc.: SD318) to rotational frequency 300rpm - 4000rpm on a light reflex layer. After spreading, ultraviolet rays were irradiated with the high-pressure mercury-vapor lamp from the upper part of a paint film, and the protective layer of 10 micrometers of thickness was formed.
[0096] In this way, multi-level record was performed using the obtained optical recording medium. Multi-level record changed the laser beam to the optical recording medium rotated with a constant linear velocity, recorded by changing the exposure power to six steps, and playback irradiated the laser beam by 1mW, making it rotate with a constant linear velocity similarly, and it reproduced it by detecting the reflected light. The used record and the evaluator are DDU(s) (record wavelength: 784nm) by the pulse tech company, and recorded the laser-beam exposure power at the time of record in six steps, (1)4.0mW, (2)4.5mW, (3)5.0mW, (4)5.4mW, (5)5.8mW, and (6)6.2mW, respectively. In addition, the record linear velocity at this time set 1.2 m/s and a record signal to 700kHz, and the duty ratio at the time of record could be (1)80.0%, (2)76.4%, (3)72.7%, (4)69.8%, (5)66.9%, and (6)64.0%, respectively.
[0097] Thus, when it recorded and the jitter value of the recorded signal was measured using the evaluator made from YOKOGAWA Electrical and electric equipment (TA320), the fluctuation by the difference in the laser-beam exposure power at the time of record was small good. Moreover, the relation (T) between the duty ratio of the maximum record power of the laser beam at this time and the duty ratio of the minimum record power was 0.8.
[0098]
[Example 2] The optical recording medium was produced like the example 1, and multi-level record was performed. Multi-level record recorded by changing the exposure power of a laser beam to the optical recording medium rotated with a constant linear velocity in six steps, and playback irradiated the laser beam by 1mW, making it rotate with a constant linear velocity similarly, and it reproduced it by detecting the reflected light. The used record and the evaluator are DDU(s) (record wavelength: 784nm) by the pulse tech company, and recorded the laser-beam exposure power at the time of record in six steps, (1)4.0mW, (2)4.5mW, (3)5.0mW, (4)5.4mW, (5)5.8mW, and (6)6.2mW, respectively. In addition, the record linear velocity at this time set 1.2 m/s and a record signal to 700kHz, and the duty ratio at the

time of record could be (1)90.0%, (2)81.8%, (3)73.6%, (4)67.1%, (5)60.5%, and (6)54.0%, respectively.

[0099] Thus, when it recorded and the jitter value of the recorded signal was measured using the evaluator made from YOKOGAWA Electrical and electric equipment (TA320), the fluctuation by the difference in the laser-beam exposure power at the time of record was small good. Moreover, the relation (T) between the duty ratio of the maximum record power of the laser beam at this time and the duty ratio of the minimum record power was 0.6.
[0100] In addition, in the evaluator of a jitter value used in these examples 1 and 2 and the following examples 1 and 2 of a comparison, if the case where it records by the conventional binary record playback approach is taken into consideration, and a jitter value is 35% or less, it can be judged as what was able to perform good record.
[0101]
[The example 1 of a comparison] The optical recording medium was produced like the example 1, and multi-level record was performed. Multi-level record recorded by changing the exposure power of a laser beam to the optical recording medium rotated with a constant linear velocity in six steps, and playback irradiated laser-beam light by 1mW, making it rotate with a constant linear velocity similarly, and it reproduced it by detecting the reflected light. The used record and the evaluator are DDU(s) (record wavelength: 784nm) by the pulse tech company, and recorded the laser-beam exposure power at the time of record in six steps, (1)4.0mW, (2)4.5mW, (3)5.0mW, (4)5.4mW, (5)5.8mW, and (6)6.2mW, respectively. In addition, the record linear velocity at this time set 1.2 m/s and a record signal to 700kHz, and the duty ratio at the time of record could be 70% uniformly.
[0102] Thus, when it recorded and the jitter value of the recorded signal was measured using the evaluator made from YOKOGAWA Electrical and electric equipment (TA320), fluctuation by the difference in the laser-beam exposure power at the time of record was large, and the jitter value when the laser-beam exposure power at the time of record is large got worse. Moreover, the relation (T) between the duty ratio of the maximum exposure power of the laser beam at this time and the duty ratio of the minimum exposure power was 1.0.
[0103]
[The example 2 of a comparison] The optical recording medium was produced like the example 1, and multi-level record was performed. Multi-level record recorded by changing the exposure power of a laser beam to the optical recording medium rotated with a constant linear velocity in six steps, and playback irradiated laser-beam light by 1mW, making it rotate with a constant linear velocity similarly, and it reproduced it by detecting the reflected light. The used record and the evaluator are DDU(s) (record wavelength: 784nm) by the pulse tech company, and recorded the laser-beam exposure power at the time of record in six steps, (1)4.0mW, (2)4.5mW, (3)5.0mW, (4)5.4mW, (5)5.8mW, and (6)6.2mW, respectively. In addition, the record linear velocity at this time set 1.2 m/s and a record signal to 700kHz, and the duty ratio at the time of record could be (1)100.0%, (2)86.4%, (3)72.7%, (4)61.8%, (5)50.9%, and (6)40.0%, respectively.
[0104] Thus, when it recorded and the jitter value of the recorded signal was measured using the evaluator made from YOKOGAWA Electrical and electric equipment (TA320), fluctuation by the difference in the laser-beam exposure power at the time of record was large, and the jitter value when the laser-beam exposure power at the time of record is large got worse. Moreover, the relation (T) between the duty ratio of the maximum exposure power of the laser beam at this time and the duty ratio of the minimum exposure power was 0.4.
[0105] The result of examples 1 and 2 and the examples 1 and 2 of a comparison is shown in a table 1.
[0106]
[A table 1]

Tの値と記録された信号のジッター値

	実施例1	実施例2	比較例1	比較例2
T：(P_1/P_2)	0．8	0．6	1．0	0．4
記録時のレーザービーム照射パワー（1）	24	23	41	43
記録時のレーザービーム照射パワー（2）	25	23	39	40
記録時のレーザービーム照射パワー（3）	25	24	37	37
記録時のレーザービーム照射パワー（4）	23	24	35	36
記録時のレーザービーム照射パワー（5）	22	23	32	33
記録時のレーザービーム照射パワー（6）	22	21	31	30

P_1：レーザービームの最大照射パワーにおけるデューティー比

P_2：レーザービームの最小照射パワーにおけるデューティー比

[0107] Next, CD-R which used coloring matter for the record layer as a record medium is used, and the examples 3-5 and the examples 3-5 of a comparison which experimented in multi-level record are explained.

[0108] As the record approach, it carried out to DDU made from a pulse tech (laser wavelength used = 784nm) used for record assessment of CD-R by connecting a RF signal generator and an acoustooptic modulator. Playback assessment also connected the digital oscilloscope to DDU, and was performed to it.

[0109] Multi-level record recorded by changing the exposure power of a 4MHz clock frequency laser beam to six steps, rotating a disk by the constant linear velocity of 4.8 m/sec, and playback irradiated the 1mW laser beam, making it rotate with a constant linear velocity similarly, and it performed it by detecting the difference of the amount of reflected lights for every virtual record cel.

[0110] In this case, the diameter of the record laser beam on record film is set to 1.6 micrometers. 0.35 micrometers with width of face equal [the size of the virtual record cel 40] to a groove and die length were set to 4.8m/4M=1.2micrometer at the groove with an overall length of 4.8m supposing the virtual record cel of 4 million.

[0111] Furthermore, the jitter value of the signal with which it was reproduced at this time was incorporated and measured to "digital oscilloscope LC[made from Le Croy]-534EL." Depending on the configuration of the record mark formed of the exposure of the laser beam to a record layer, the more a jitter value has a small jitter value, the more it means that said record mark is formed certainly. This is synonymous with the ability of information to record certainly, therefore can also ensure playback.

[0112] In the measurement machine of a jitter value used in examples 3-5 and the examples 3-5 of a comparison, if the case where it records by the conventional binary record playback approach is taken into consideration, and it is 10% or less of jitter values, it can be judged as what was able to perform good record.

[0113] ** is just shown in each examples 3-5 and the examples 3-5 of a comparison concretely below.

[0114]

[Example 3] Dissolve cyanine dye in the fluorination alcohol used as a spreading solvent, and 2% of coloring matter solution for record stratification is prepared. About this solution, it is a spiral-like pre groove (track pitch: 1.6 micrometers) to a front face. Pre groove width of face : The diameter of 120mm which 0.35 micrometers and depth:0.18micrometer of a pre groove become from the polycarbonate (Made in formation [Teijin] : the panlight AD 5503) formed of injection molding, It applied to the pre

groove side front face of the light transmission nature substrate of 1.2mm thickness with the spin coat method, making it change to rotational frequency 200rpm - 5000rpm, and the organic-coloring-matter record layer from which the thickness from the pars basilaris ossis occipitalis in a pre groove is set to about 200nm was formed in it. In addition, what recorded beforehand the distinction signal which shows that this optical recording medium is used for multi-level record, and the information signal about laser-beam exposure power was used for the light transmission nature substrate used here.

[0115] Next, on the organic-coloring-matter record layer, sputtering of Ag was carried out by the thickness of about 100nm, and the light reflex layer was formed. Furthermore, it applied with the spin coat method, changing ultraviolet-rays hardenability resin (Dainippon Ink & Chemicals, Inc.: SD318) to rotational frequency 300rpm - 4000rpm on a light reflex layer. After spreading, ultraviolet rays were irradiated with the high-pressure mercury-vapor lamp from the upper part of a paint film, and the protective layer of 10 micrometers of thickness was formed.

[0116] In this way, multi-level record was performed using the obtained optical recording medium. Multi-level record recorded by changing the exposure power of a laser beam to the optical recording medium rotated with a constant linear velocity in six steps, and playback irradiated the laser beam by 1mW, making it rotate with a constant linear velocity similarly, and it reproduced it by detecting the reflected light. The used record and the evaluator are DDU(s) (record wavelength: 784nm) by the pulse tech company, and set the laser-beam exposure power at the time of record as 14mW at the maximum.

[0117] The exposure power of the laser beam at the time of record was recorded in six steps, (1)3.5mW, (2)5.6mW, (3)7.7mW, (4)9.8mW, (5)11.9mW, and (6)14mW, respectively. The single signal was recorded over 1 round of disks for every exposure power at the time of record.

[0118] Here, the minimum exposure power ES is (1)3.5mW, and the maximum exposure power EL is set to (6)14mW. Therefore, the ratio (ES/EL) is 0.250 and is filling the above-mentioned relational expression (1). By this disk, six steps of multi-level records are attained, and that record data was able to be read certainly. In addition, although the jitter value of the above (1) in this medium - (6) record mark is shown in the following table, it turns out that 10% or less of good assessment is obtained in all record marks.

[0119]

[Example 4] The optical recording medium was produced like the example 3.

[0120] The record linear velocity in the case of multi-level record was 4.8 m/s, the clock frequency of record was set to 4MHz, and the exposure power of a laser beam could be (1)5.8mW, (2)7.3mW, (3) 8.7mW, (4)10.1mW, (5)11.5mW, and (6)13mW, respectively. In addition, each single signal was recorded over 1 round of disks.

[0121] Here, the minimum exposure power ES is (1)5.8mW, and the maximum exposure power EL is (6)13mW. Therefore, the ratio (ES/EL) is 0.446 and is filling the above-mentioned relational expression (1). By this disk, six steps of multi-level records are attained, and that record data was able to be read certainly. In addition, although the jitter value of the above (1) in this medium - (6) record mark is shown in the following table, it turns out that 10% or less of good assessment is obtained in all record marks.

[0122]

[Example 5] The optical recording medium was produced like the example 3.

[0123] The record linear velocity in the case of multi-level record was 4.8 m/s, the clock frequency of record was set to 4MHz, and the exposure power of a laser beam could be (1)1mW, (2)4mW, (3)6.6mW, (4)9.4mW, (5)12.2mW, and (6)15mW, respectively. In addition, each single signal was recorded over 1 round of disks.

[0124] Here, the minimum exposure power ES is (1)1mW, and the maximum exposure power EL is (6) 15mW. Therefore, the ratio (ES/EL) is 0.066 and is filling the above-mentioned relational expression (1). By this disk, six steps of multi-level records are attained, and that record data was able to be read certainly. In addition, although the jitter value of the above (1) in this medium - (6) record mark is shown in the following table, it turns out that 10% or less of good assessment is obtained in all record marks.

[0125]
[The example 3 of a comparison] The optical recording medium was produced like the example 3.
[0126] The record linear velocity at the time of multi-level record was 4.8m/s, the clock frequency of record was set to 4MHz, and laser-beam exposure power could be (1)0.6mW, (2)4.1mW, (3)7.0mW, (4) 10.6mW, (5)14.0mW, and (6)17mW, respectively. In addition, each single signal was recorded over 1 round of disks.
[0127] Here, the minimum record power ES is (1)0.6mW, and the maximum record power EL is (6) 17mW. Therefore, the ratio (ES/EL) is 0.035, was not able to fill the above-mentioned relational expression (1), and was not able to read certainly the record data of six steps of multi-level records by this disk. In addition, although the jitter value of the record mark of above-mentioned (1) - (6) in this medium is shown in the following table, it turns out that it is over 10% in all record marks, and sufficient assessment is not obtained.
[0128]
[The example 4 of a comparison] The optical recording medium was produced like the example 3.
[0129] The record linear velocity at the time of multi-level record was 4.8m/s, the clock frequency of record was set to 4MHz, and laser-beam exposure power could be (1)6.5mW, (2)7.6mW, (3)8.7mW, (4) 9.8mW, (5)10.9mW, and (6)12mW, respectively. In addition, each single signal was recorded over 1 round of disks.
[0130] Here, the minimum exposure power ES is (1)6.5mW, and the maximum exposure power EL is (6)12mW. Therefore, the ratio (ES/EL) is 0.542, was not able to fill the above-mentioned relational expression (1), and was not able to read certainly the record data of six steps of multi-level records by this disk. In addition, although the jitter value of the record mark of above-mentioned (1) - (6) in this medium is shown in the following table, it turns out that it is over 10% in a great portion of record mark, and sufficient assessment is not obtained.
[0131]
[The example 5 of a comparison] CD-RW was used as a record medium and multi-level record was performed.
[0132] The phase change film with which this CD-RW is constituted as a record layer not including organic coloring matter but including Ag-In-Sb-Te is formed, light transmittance changes because this phase change film carries out physical transition with a crystalline substance (crystal) while it is noncrystalline (amorphous), and data are recorded.
[0133] In this CD-RW, the record linear velocity at the time of record was 4.8 m/s, the clock frequency of record was set to 4MHz, and laser-beam exposure power could be (1)8.5mW, (2)9.2mW, (3)9.9mW, (4)10.6mW, (5)11.3mW, and (6)12mW, respectively. In addition, each single signal was recorded over 1 round of disks.
[0134] Here, the minimum exposure power ES is (1)8.5mW, and the maximum exposure power EL is (6)12mW. Therefore, the ratio (ES/EL) is 0.708 and is not filling the above-mentioned relational expression (1). In this CD-RW, the record data of six steps of multi-level records were not able to be read certainly. In addition, although the jitter value of the record mark of above-mentioned (1) - (6) in this medium is shown in the following table, it turns out that it is over 10% in all record marks, and has become bad assessment from the example 4 (ES/EL=0.542) of a comparison further.
[0135]
[A table 2]

ＥＳ／ＥＬの値と記録された信号のジッター値

		実施例3	実施例4	実施例5	比較例3	比較例4	比較例5
ＥＳ／ＥＬ		0.250	0.444	0.063	0.034	0.545	0.707
各ジッター値（%）	レーザービーム照射パワー（1）	5.5	7.1	8.3	11.5	11.5	13.1
	レーザービーム照射パワー（2）	5.4	7.2	8.4	11.0	10.5	12.5
	レーザービーム照射パワー（3）	5.3	7.1	8.1	10.5	10.2	12.3
	レーザービーム照射パワー（4）	5.3	7.1	8.8	10.6	9.9	12.5
	レーザービーム照射パワー（5）	5.3	8.4	9.1	11.2	10.6	12.9
	レーザービーム照射パワー（6）	5.2	8.5	9.2	11.1	10.8	13.0

ＥＳ（秒）：レーザービームの最小照射パワー

ＥＬ（秒）：レーザービームの最大照射パワー

[0136]
[Effect of the Invention] According to the optical recording approach and optical recording medium concerning this invention, according to the data with which record is presented, it can record on a multi-level, and the property of the reading signal from the record mark can be further made good.

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The perspective view showing the important section of the optical recording medium concerning the example of the gestalt of operation of this invention made into the cross section in part
[Drawing 2] The block diagram showing the optical recording equipment for using a laser beam for this optical recording medium, and recording information
[Drawing 3] The mimetic diagram showing the relation between this record mark and virtual record cel at the time of forming a record mark in a record layer with this optical recording equipment, and its rate of a light reflex
[Drawing 4] The sketch perspective view showing the case where the laser beam which irradiates a virtual record cel is made into other configurations
[Description of Notations]
10 -- Optical recording medium
12 -- Record layer
14 -- Substrate
16 -- Groove
18 -- Reflective film
20 -- Protective layer
30 -- Optical recording equipment
32 -- Spindle
36 -- Laser
38 -- Laser driver
40 -- Virtual record cel
41 -- Modulator
42 -- Record optical system
42A -- Objective lens
42B -- Half mirror
42C -- Cylindrical lens
44 -- Focus servo circuit
46 -- Feeding servo circuit
49 48A-48G, 54 -- Record mark
52 -- Pit
56 -- Groove interruption section
D -- Beam

[Translation done.]

* NOTICES *

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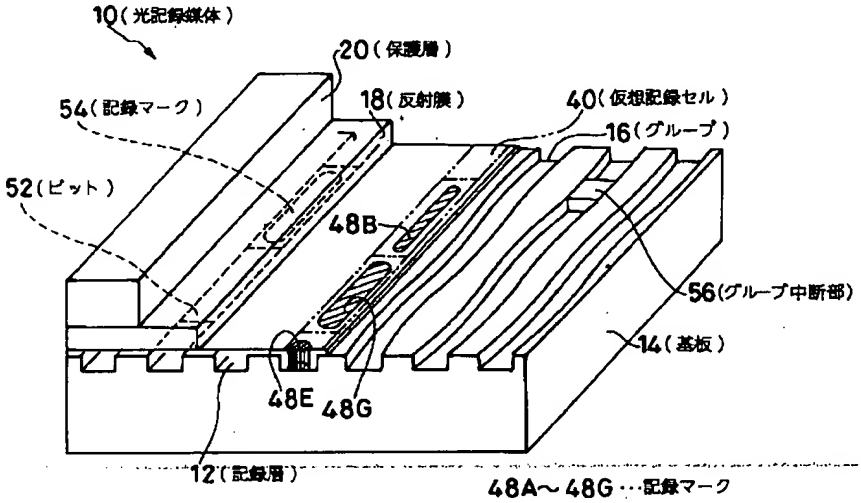
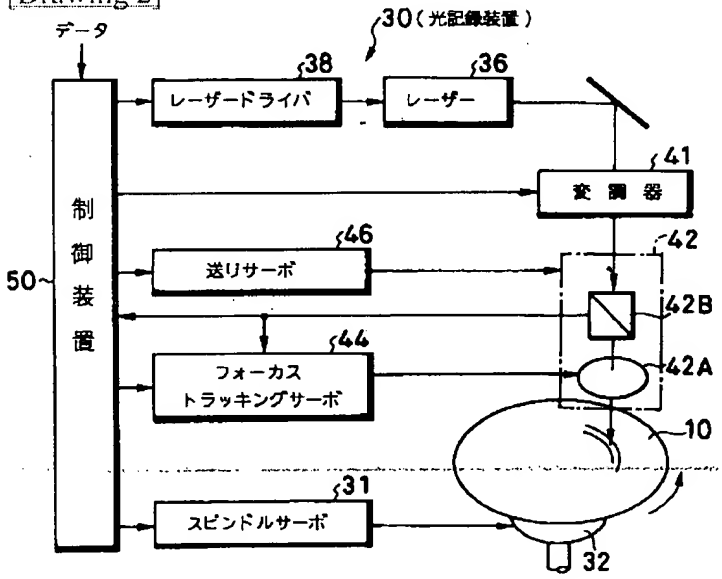
3.In the drawings, any words are not translated.

DRAWINGS

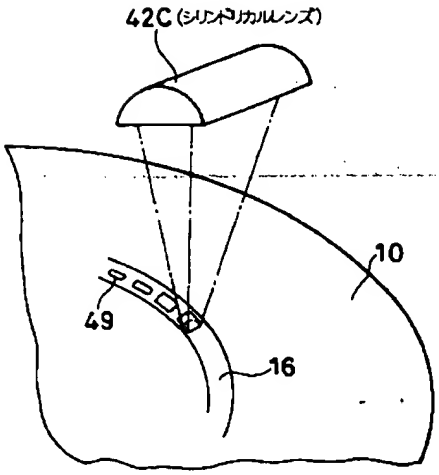
[Drawing 1]



[Drawing 2]

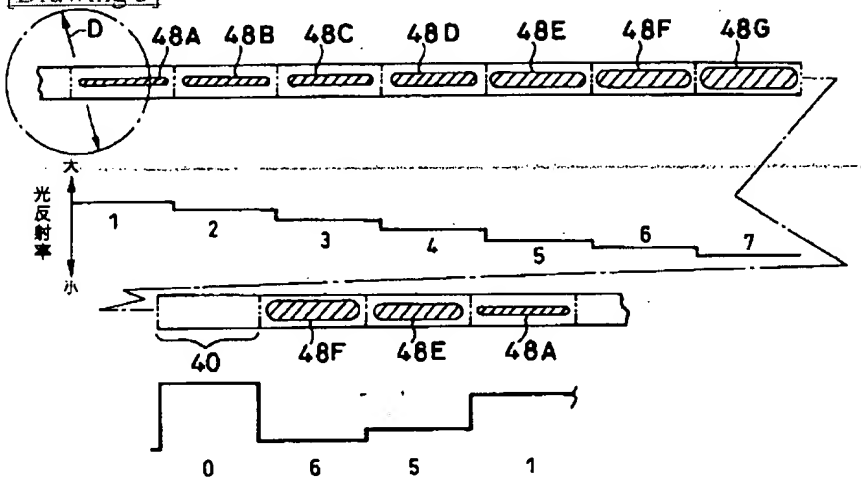


[Drawing 4]



49・・・記録マーク

[Drawing 3]



[Translation done.]